
Bibliography.

---

(19) [Country of Issue] Japan Patent Office (JP)
(12) [Official Gazette Type] Open patent official report (A).
(11) [Publication No.] JP,8-264478,A.
(43) [Date of Publication] October 11, Heisei 8 (1996).
(54) [Title of the Invention] The electrode formation method of a gallium-nitride system compound semiconductor.
(51) [International Patent Classification (6th Edition)]
H01L 21/28
33/00
[FI]
H01L 21/28 A
33/00 E
[Request for Examination] Un-asking.
[The number of claims] 6.
[Mode of Application] FD.
[Number of Pages] 4.
(21) [Filing Number] Japanese Patent Application No. 7-94484.
(22) [Filing Date] March 27, Heisei 7 (1995).
(71) [Applicant]
[Identification Number] 000241463.
[Name] TOYODA GOSEI CO., LTD.
[Address] 1, Nagahata, Ochiai, Haruhi-cho, Nishi-Kasugai-gun, Aichi-ken.
(71) [Applicant]
[Identification Number] 390014535.
[Name] Research Development Corp. of Japan.
[Address] 4-1-8, Hon-cho, Kawaguchi-shi, Saitama-ken.
(72) [Inventor(s)]
[Name] Pool Masayoshi.
[Address] 1, Nagahata, Ochiai, Haruhi-cho, Nishi-Kasugai-gun, Aichi-ken Inside of TOYODA GOSEI CO., LTD.
(72) [Inventor(s)]
[Name] Nagai Sincerity 2.
[Address] 1, Nagahata, Ochiai, Haruhi-cho, Nishi-Kasugai-gun, Aichi-ken Inside of TOYODA GOSEI CO., LTD.
(72) [Inventor(s)]
[Name] Yamasaki Shiro.

[Address] 1, Nagahata, Ochiai, Haruhi-cho, Nishi-Kasugai-gun, Aichi-ken Inside of TOYODA GOSEI CO., LTD.
(72) [Inventor(s)]
[Name] Murakami Masanori.
[Address] 22-32, **************, Tsuzuki-gun, Kyoto.
(72) [Inventor(s)]
[Name] Tsukui Katsuyuki.
[Address] 102-1, **********************, Sakyo-ku, Kyoto-shi.
(72) [Inventor(s)]
[Name] Ishikawa Hidenori.
[Address] 307, **************************, Kamigyo-ku, Kyoto-shi.
(74) [Attorney]
[Patent Attorney]
[Name] Fujitani **.

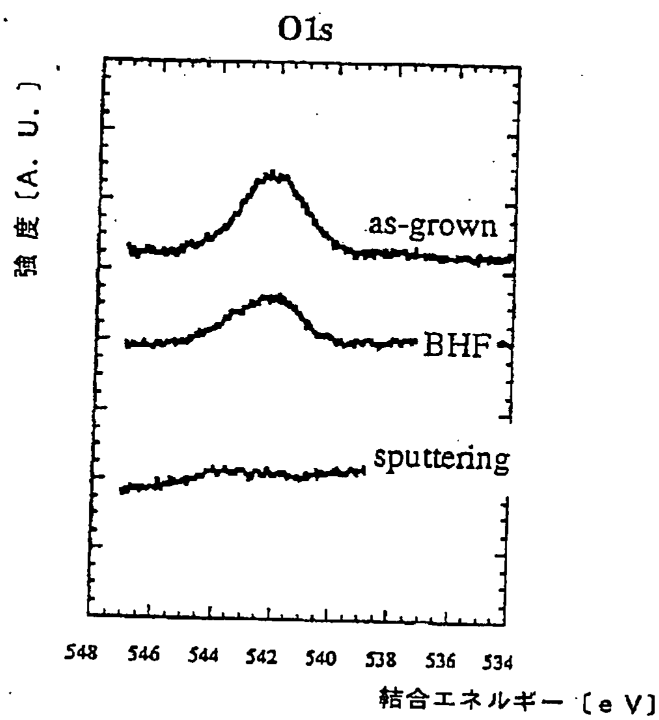
[Translation done.]

Summary.

---

(57) [Abstract]
[Objects of the Invention] The fall of the contact resistance of the electrode in a gallium-nitride system compound semiconductor. [Elements of the Invention] The oxide and affix on the front face of a semiconductor are completely removed by carrying out reverse sputtering using inert gas by using as a target the front face of the compound semiconductor which contains a gallium and nitrogen at least. The grade of reverse sputtering was made into the grade by which the destructive layer by which the atomic arrangement was destroyed is formed in a semiconductor front face, and the contact resistance of a metal and a semiconductor fell by holding a vacua and performing a metal vacuum evaporationo process and continuing alloy down stream processing succeeding a sputtering process. Contact resistance fell to 1/10 compared with the case where an electrode is formed in the front face which carried out wet etching by BHF.

[Translation done.]



[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The electrode formation method characterized by carrying out the vacuum evaporationo of the metal and forming an electrode after carrying out sputtering of the front face of the compound semiconductor which contains a gallium and nitrogen at least using inert gas.

[Claim 2] The surface atomic layer of the aforementioned semiconductor is the electrode formation method according to claim 1 characterized by forming the destructive layer in which the atomic arrangement was confused by sputtering which used the aforementioned inert gas.

[Claim 3] Furthermore, the electrode formation method according to claim 1 or 2 characterized by performing alloying processing after depositing a metal on the front face of the aforementioned semiconductor.

[Claim 4] The process which carries out the vacuum evaporationo of the metal to the front face of the aforementioned semiconductor is the electrode formation method according to claim 1 to 3 which is in the state held at the vacuum and is characterized by performing succeeding sputtering.

[Claim 5] The aforementioned alloying processing is the electrode formation method according to claim 3 which is in the state held at the vacuum and is characterized by performing succeeding the aforementioned vacuum evaporationo process.
[Claim 6] The aforementioned inert gas is the electrode formation method according to claim 1 to 5 characterized by being argon (Ar) gas.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention improves ohmic nature and relates to the etching method of the gallium-nitride system compound semiconductor for reducing contact resistance especially.
[0002]
[Description of the Prior Art] Gallium-nitride system compound semiconductor (AlGaInN) It is the material which attracts attention as blue light emitting diode. After performing wet chemical etching, using medical fluids, such as BHF, as a method of forming an electrode in this semiconductor front face, the method of carrying out vacuum deposition of the various metals, such as nickel and aluminum, to an etching side is learned.
[0003]
[Problem(s) to be Solved by the Invention] However, by this method, since a semiconductor front face was not washed completely, it had become what deposited the metal on an oxide or other affixes as a result. For this reason, there was a problem that the contact resistance of an electrode was high.
[0004] Therefore, the purpose of this invention is reducing the contact resistance of the metal electrode and semiconductor, when forming a metal electrode in the front face of the gallium-nitride system compound semiconductor which contains a gallium and nitrogen at least.
[0005]
[Means for Solving the Problem] After the 1st feature of invention for solving the above-mentioned technical problem carries out sputtering of the front face of the compound semiconductor which contains a gallium and nitrogen at least using inert gas, it is characterized by carrying out the vacuum evaporationo of the metal and forming an electrode. The 2nd feature is characterized by the grade of sputtering of having used inert gas being a grade by which the destructive layer in which the atomic arrangement was confused is formed in the surface atomic layer of a semiconductor. Moreover, further, after the 3rd feature deposits a metal on the surface of a semiconductor, it is characterized by performing alloying processing. Moreover, the process to which the 4th invention carries out the vacuum evaporationo of the metal on the surface of a semiconductor is in the state held at the

vacuum, and the feature of performing succeeding sputtering is carried out, and the 5th feature is in the state where alloying processing was held at the vacuum, and it is characterized by performing succeeding a vacuum evaporationo process. Furthermore, the 6th feature is characterized by using argon (Ar) gas for inert gas.

[0006]

[Function and Effect] The oxide and affix on the front face of a semiconductor were completely removable by carrying out reverse sputtering using inert gas by using as a target the front face of the compound semiconductor which contains a gallium and nitrogen at least. Consequently, when a metal was deposited on this field, the contact resistance of a metal and a semiconductor became small.

[0007] Moreover, the contact resistance of a metal and a semiconductor was able to be reduced by making the grade of reverse sputtering into the grade by which the destructive layer by which the atomic arrangement was destroyed is formed in a semiconductor front face. Moreover, it became the smallest [the contact resistance of a semiconductor and a metal] by the contact resistance of a metal and a semiconductor falling further by holding a vacua for a metal vacuum evaporationo process, and performing succeeding a sputtering process, holding a vacua further, and performing alloying processing following the vacuum deposition process, and ohmic nature also became best. If a destructive layer was formed in a semiconductor front face, since alloying processing of a vacuum evaporationo metal would be performed effectively, contact resistance became very small.

[0008]

[Example] Hereafter, this invention is explained based on a concrete example. Compound semiconductor which contains a gallium and nitrogen at least (AlGaInN) GaN was used as an example. The GaN substrate washed by the target of the chamber of a sputtering system was placed. Next, acceleration voltage 200 V and current density [of 20micro] A/cm2 Incidence of the argon ion is carried out from a normal by the Kauffmann type ion gun, and it is GaN. Sputtering of the target of a substrate was carried out.

[0009] Next, GaN The substrate was placed into the chamber of the above-mentioned sputtering system, and where the inside of a chamber is held to a vacuum, the vacuum evaporationo of the nickel (nickel) was usually carried out to the front face of a GaN substrate by sputtering. The heat-treatment of nickel by which vacuum evaporationo was carried out, i.e., alloying processing, was performed after vacuum evaporationo using the same chamber.

[0010] The contact resistance of the metal electrode obtained by the above-mentioned processing was severalohms. Since contact resistance was several 10ohms when the vacuum evaporationo of the nickel electrode is carried out to the field as for which wet etching was carried out by conventional BHF and an electrode is formed in it, contact resistance was able to be reduced to 1/10 by this invention method.

[0011] Moreover, Light Emitting Diode was manufactured using the gallium-nitride system compound semiconductor, and the above-mentioned method was used for the electrode formation. Luminous efficiency and endurance of Light Emitting Diode using such an electrode improved.

[0012] In addition, in the above-mentioned example, although the vacuum evaporationo metal was used as nickel, they may be aluminum, gold, and titanium. Moreover, although the vacuum evaporationo by sputtering was performed, a vacuum physical vapor deposition is sufficient. Furthermore, it is made to move to the vacuum evaporation system which followed the sputtering system at the time of vacuum evaporationo, without touching the open air with a sample, and may be made to carry out the vacuum evaporationo of the metal by electron beam evaporation, resistance heating vacuum evaporationo, etc. with the vacuum evaporationo equipment to it. Furthermore, without making the open air touched with a sample, it may be made to move into the vacuum devices which followed the sputtering system similarly, and lamp heating etc. may also perform alloying

processing.

[0013] Next, in order to confirm the cleaning effect by argon sputtering, the next comparative experiments were conducted. It is AlN on silicon on sapphire. The buffer stratification is carried out and it is GaN on the buffer layer. The layer was formed. This three sample was prepared. GaN of the 1st sample About the layer, the component element of the crystal of a surface layer was analyzed by X-ray photoelectron spectroscopy (XPS). As shown in drawing 1 and drawing 2 , it turns out that oxygen and carbon exist in the surface layer. Next, GaN of the 2nd sample Above GaN [layer] Wet etching of the front face of a layer was carried out by BHF, and the component element of the crystal of a surface layer was similarly analyzed by X-ray photoelectron spectroscopy (XPS). Although the coating weight of the oxygen in a surface layer and carbon is decreasing compared with the former so that drawing 1 and drawing 2 may show, it turns out too that oxygen and carbon are not removed completely. Next, GaN of the 3rd sample An argon is used about a layer and it is GaN. After carrying out sputtering of the layer, the component element of the crystal of the field was analyzed by X-ray photoelectron spectroscopy (XPS). When sputtering of the front face is carried out with an argon so that drawing 1 and drawing 2 may show, it turns out that oxygen and carbon are completely removable from a surface layer.

[0014] Next, the time of the spatter rig by the argon is changed and it is GaN by X-ray photoelectron spectroscopy (XPS). The component element of the crystal of the spatter side of a layer was analyzed. A result is shown in drawing 3 . About 120 sec(s) By sputtering, it turns out that oxygen and carbon are removable from a surface layer.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] GaN Measurement view which measured the surface oxygen element processed by various kinds of methods of a layer by X-ray photoelectron spectroscopy (XPS).

[Drawing 2] GaN Measurement view which measured the surface oxygen carbon processed by various kinds of methods of a layer by X-ray photoelectron spectroscopy (XPS).

[Drawing 3] GaN Measurement view which measured the sputtering time and the surface amount of elements by the argon of the front face of a layer, and ****** by X-ray photoelectron spectroscopy (XPS).

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

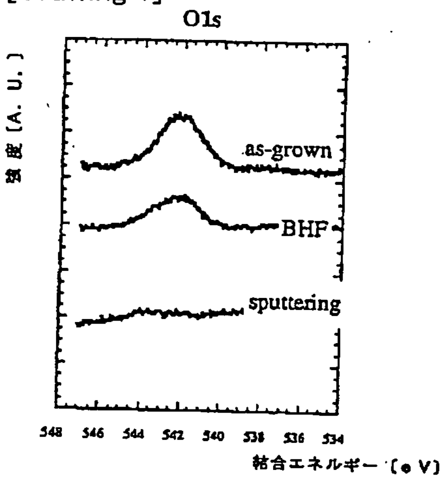
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

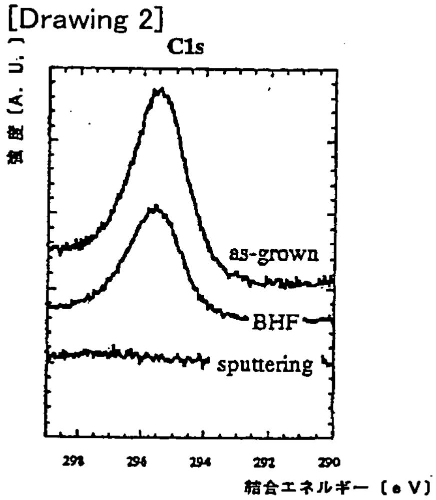
3.In the drawings, any words are not translated.

DRAWINGS

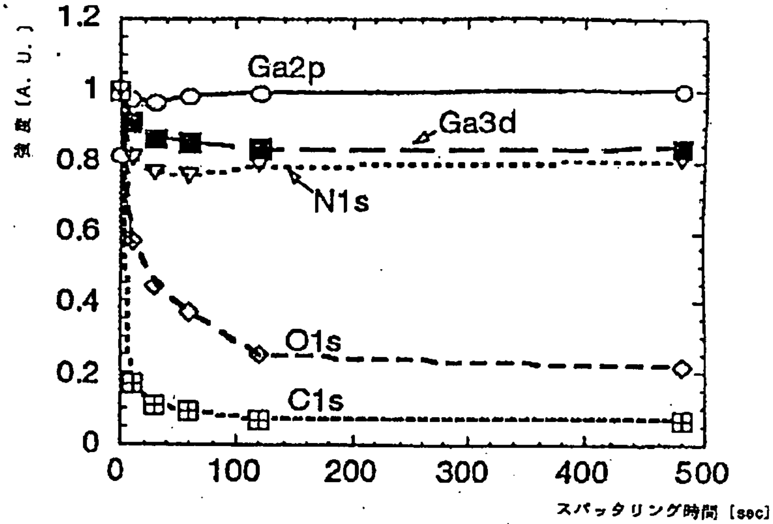
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号

特開平8－264478

(43)公開日　平成８年(1996)10月11日

(51)Int.Cl.⁶	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　21/28			Ｈ０１Ｌ　21/28	Ａ
33/00			33/00	Ｅ

審査請求　未請求　請求項の数６　ＦＤ　（全　４　頁）

(21)出願番号　特願平7－94484

(22)出願日　平成７年(1995)３月27日

(71)出願人　000241463
豊田合成株式会社
愛知県西春日井郡春日町大字落合字長畑１番地

(71)出願人　390014535
新技術事業団
埼玉県川口市本町４丁目１番８号

(72)発明者　小池　正好
愛知県西春日井郡春日町大字落合字長畑１番地　豊田合成株式会社内

(74)代理人　弁理士　藤谷　修

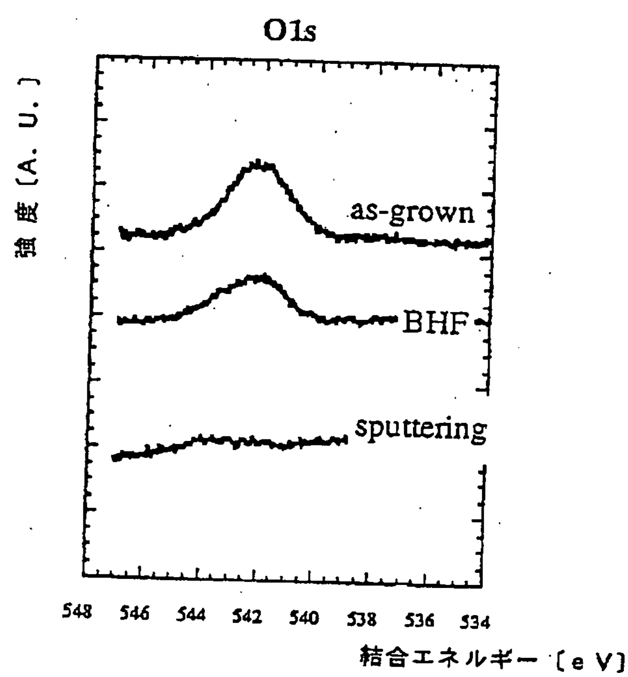
最終頁に続く

(54)【発明の名称】　窒化ガリウム系化合物半導体の電極形成方法

(57)【要約】

【目的】　窒化ガリウム系化合物半導体における電極の接触抵抗の低下

【構成】　少なくともガリウム及び窒素を含む化合物半導体の表面をターゲットとして、不活性ガスを用いて逆スパッタリングすることで、半導体表面の酸化物や付着物を完全に除去する。逆スパッタリングの程度を半導体表面に原子配列が破壊された破壊層が形成される程度とし、金属蒸着工程と続く合金処理工程を真空状態を保持してスパッタリング工程に連続して実行することで、金属と半導体との接触抵抗が低下した。ＢＨＦによりウエットエッチングした表面に電極を形成した場合に比べて、接触抵抗は１／１０に低下した。



【特許請求の範囲】

【請求項1】　少なくともガリウム及び窒素を含む化合物半導体の表面を不活性ガスを用いてスパッタリングした後に、金属を蒸着して電極を形成することを特徴とする電極形成方法。

【請求項2】　前記半導体の表面原子層は、前記不活性ガスを用いたスパッタリングにより原子配列の乱れた破壊層が形成されることを特徴とする請求項1に記載の電極形成方法。

【請求項3】　さらに、前記半導体の表面に金属を蒸着した後、合金化処理が行われることを特徴とする請求項1又は請求項2に記載の電極形成方法。

【請求項4】　前記半導体の表面に金属を蒸着する工程は、真空に保持された状態で、スパッタリングに連続して実行されることを特徴とする請求項1乃至請求項3に記載の電極形成方法。

【請求項5】　前記合金化処理は、真空に保持された状態で、前記蒸着工程に連続して実行されることを特徴とする請求項3に記載の電極形成方法。

【請求項6】　前記不活性ガスはアルゴン(Ar)ガスであることを特徴とする請求項1乃至請求項5に記載の電極形成方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、オーミック性を改良し、特に、接触抵抗を低下させるための窒化ガリウム系化合物半導体のエッチング方法に関する。

【0002】

【従来の技術】窒化ガリウム系化合物半導体(AlGaInN)は青色発光ダイオードとして注目されている材料である。この半導体表面に電極を形成する方法として、ＢＨＦ等の薬液を用いてウエットケミカルエッチングを行った後、エッチング面にニッケル、アルミニウム等の種々の金属を真空蒸着する方法が知られている。

【0003】

【発明が解決しようとする課題】しかしながら、この方法では、半導体表面が完全には洗浄されないため、結果的に、酸化物やその他の付着物の上に金属を蒸着したものとなっていた。このため、電極の接触抵抗が高いという問題があった。

【0004】したがって、本発明の目的は、少なくともガリウムと窒素とを含む窒化ガリウム系化合物半導体の表面に金属電極を形成するとき、その金属電極と半導体との接触抵抗を低下させることである。

【0005】

【課題を解決するための手段】上記課題を解決するための発明の第1の特徴は、少なくともガリウム及び窒素を含む化合物半導体の表面を不活性ガスを用いてスパッタリングした後に、金属を蒸着して電極を形成することを特徴とする。第2の特徴は、不活性ガスを用いたスパッタリングの程度が、半導体の表面原子層に原子配列の乱れた破壊層が形成される程度であることを特徴とする。又、第3の特徴は、さらに、半導体の表面に金属を蒸着した後、合金化処理が行われることを特徴とする。又、第4の発明は、半導体の表面に金属を蒸着する工程は、真空に保持された状態で、スパッタリングに連続して実行されることを特徴し、第5の特徴は、合金化処理が、真空に保持された状態で、蒸着工程に連続して実行されることを特徴とする。さらに、第6の特徴は、不活性ガスにアルゴン(Ar)ガスが用いられていることを特徴とする。

【0006】

【作用及び効果】少なくともガリウム及び窒素を含む化合物半導体の表面をターゲットとして、不活性ガスを用いて逆スパッタリングすることで、半導体表面の酸化物や付着物を完全に除去することができた。この結果、この面の上に金属を蒸着した場合に金属と半導体との接触抵抗が小さくなった。

【0007】又、逆スパッタリングの程度を半導体表面に原子配列が破壊された破壊層が形成される程度とすることで、金属と半導体との接触抵抗を低下させることができた。又、金属蒸着工程を真空状態を保持してスパッタリング工程に連続して実行することで、金属と半導体との接触抵抗がさらに低下し、さらに、真空状態を保持して、その真空蒸着工程に続いて合金化処理を行うことで、半導体と金属との接触抵抗は、最も小さくなり、オーミック性も最良となった。半導体表面に破壊層が形成されると、蒸着金属の合金化処理が効果的に行われるため、接触抵抗が極めて小さくなった。

【0008】

【実施例】以下、本発明を具体的な実施例に基づいて説明する。少なくともガリウム及び窒素を含む化合物半導体(AlGaInN) の一例としてGaNが用いられた。スパッタリング装置のチャンバーのターゲットに洗浄されたGaN基板が置かれた。次に、加速電圧２００Ｖ、電流密度２０μＡ／cm^2 で、アルゴンイオンをカウフマン型イオン銃で法線方向から入射し、GaN 基板のターゲットがスパッタリングされた。

【0009】次に、GaN 基板が上記のスパッタリング装置のチャンバー内に置かれ、チャンバー内を真空に保持した状態で、通常スパッタリングによりニッケル(Ni)がGaN基板の表面に蒸着された。蒸着の後、同一チャンバーを用いて、蒸着されたニッケルの加熱処理、即ち、合金化処理が実行された。

【0010】上記の処理により得られた金属電極の接触抵抗は数Ωであった。従来のＢＨＦによりウエットエッチングされた面にニッケル電極を蒸着して電極を形成した場合には、接触抵抗は数１０Ωであるので、本発明方法により、接触抵抗は１／１０に低下させることができた。

【００１１】又、窒化ガリウム系化合物半導体を用いてＬＥＤを製造し、その電極形成に上記の方法を用いた。このような電極を用いたＬＥＤは発光効率及び耐久性が向上した。

【００１２】尚、上記の実施例では、蒸着金属はニッケルとしたが、アルミニウム、金、チタンであっても良い。又、スパッタリングによる蒸着を行ったが真空物理蒸着でも良い。さらに、蒸着時にはスパッタリング装置に連続した真空蒸着装置に、試料を外気に触れることなく移動させて、その蒸着装置で金属を電子ビーム蒸着、抵抗加熱蒸着等により蒸着するようにしても良い。さらに、合金化処理も試料を外気に触れさせることなく同様にスパッタリング装置に連続した真空装置内に移動させてランプ加熱等により行っても良い。

【００１３】次に、アルゴンスパッタリングによる洗浄効果を確かめるために、次の比較実験を行った。サファイア基板上にAlN をバッファ層形成し、そのバッファ層上にGaN 層を形成した。この試料が３つ準備された。第１の試料のGaN 層について、Ｘ線光電子分光法（ＸＰＳ）により表面層の結晶の成分元素を分析した。図１と図２に示すように、酸素と炭素が表面層に存在していることが分かる。次に、第２の試料のGaN 層について、上記のGaN 層の表面をＢＨＦでウエットエッチングして、同様にＸ線光電子分光法（ＸＰＳ）により表面層の結晶の成分元素を分析した。図１、図２から分かるように、前者に比べて、表面層における酸素と炭素の付着量は減少しているが、やはり、酸素と炭素は完全には除去されていないことが分かる。次に、第３の試料のGaN 層について、アルゴンを用いてGaN 層をスパッタリングした後、Ｘ線光電子分光法（ＸＰＳ）によりその面の結晶の成分元素を分析した。図１、図２から分かるように、アルゴンで表面をスパッタリングすると、表面層から完全に酸素と炭素を除去できることが分かる。

【００１４】次に、アルゴンによるスパッタリグの時間を変化させて、Ｘ線光電子分光法（ＸＰＳ）によりGaN 層のスパッタ面の結晶の成分元素を分析した。結果を図３に示す。約１２０sec のスパッタリングで、表面層から酸素と炭素を除去できることが分かる。

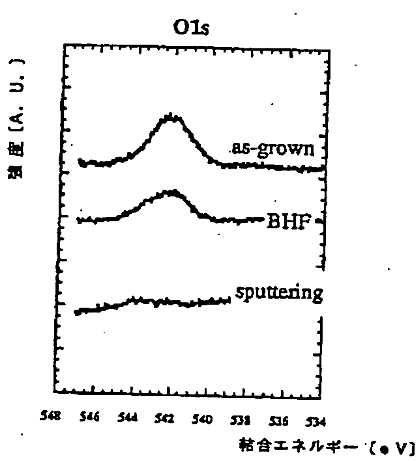
【図面の簡単な説明】

【図１】GaN 層の各種の方法で処理された表面の酸素元素をＸ線光電子分光法（ＸＰＳ）で測定した測定図。

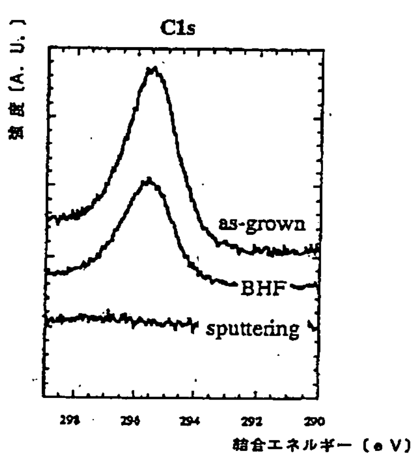
【図２】GaN 層の各種の方法で処理された表面の酸素炭素をＸ線光電子分光法（ＸＰＳ）で測定した測定図。

【図３】GaN 層の表面のアルゴンによるスパッタリング時間と表面の元素量と関係ををＸ線光電子分光法（ＸＰＳ）で測定した測定図。

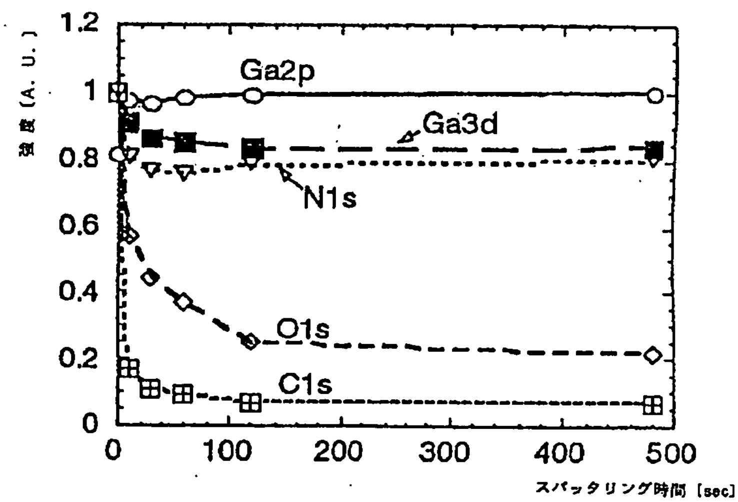
【図１】



【図２】



【図3】



フロントページの続き

(72)発明者　永井　誠二
愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内

(72)発明者　山崎　史郎
愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内

(72)発明者　村上　正紀
京都府綴喜郡田辺町薪長尾谷22－32

(72)発明者　津久井　克幸
京都市左京区川端通夷川上る新生洲町102－1

(72)発明者　石川　英憲
京都市上京区新烏丸通り丸太町上ル新富町307